HIRDLS

HIGH RESOLUTION DYNAMICS LIMB SOUNDER

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Subject / Title: Radiometric and Line of Sight Verification Requirements

Contents / Description / Summary:

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Key Words:

Purpose (20 characters maximum):

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EOS

The primary purpose of the following table is to show the radiometric and pointing requirements which must be verified by test, as opposed to analysis or inspection. The table also shows the minimum level of integration at which the test(s) must be performed. Entries in the Level and Field of Regard columns apply only to the 'Test' method of verification. The Field of Regard entry lists the range and minimum test data set.

Para. No	Description	Method (Note 1)	Level (Note 2)	Field of Regard (Notes 3,4,5)	Comments
3.3.1	Vertical Field of View	A			
3.3.2	Vertical Response				
	FWHM	T, A	TSS+DSS	Az: –SE, SZ, +SE El: –SE, SZ, +SE	9 points
	Integrated Vertical Response	T	Inst	Az: SZ El: –SE, SZ, +SE	3 points
3.3.3	Vertical Response Stability	N/A			
3.3.3.1	Within a Single Channel	A			
3.3.3.2	Between Channels	T, A	TSS+DSS	BS	
3.3.4	Horizontal Field of View	A			
3.3.5	Out-of-Field Response	T, A	Inst	Az: –SE → +SE El: –SE → +SE	TBD increments in Az & El
3.4	Radiometric Specifications	N/A			
3.4.1	Channel Spectral Response	T	Inst	BS	
3.4.2	Spectral Response Stability	A			
3.4.3	Out-of-Band Response	T, A	TSS+	BS	
3.4.4	Radiometric Performance	N/A			
3.4.4.1	Radiometric Accuracy	T	Inst	Az: –SE → +SE El: –SE → +SE IFC	TBD increments in Az & El TBD Blackbody Temperatures
3.4.4.2	Radiometric Channel Gain	T	Inst	BS	
3.4.4.2.1	Radiometric Channel Gain Stability	T	Inst	BS	
3.4.4.3	Radiometric Channel Offset	T	Inst	BS	
3.4.4.3.1	Radiometric Channel Offset Stability	T, A	Inst	BS	
3.4.4.4	End-to-End Channel Linearity	T	Inst	BS	
3.4.4.5	Electrical Crosstalk	T	Inst	BS	
3.4.5	Radiometric Noise	T	Inst	Az: SZ El: Scanning IFC	
3.4.6	Dynamic Range	T, A	Inst	BS	
3.4.7	Radiometric Digitization	N/A			
3.4.7.1	Radiometric Quantization Error	A			
3.4.7.2	Radiometric Quantization Step Size Uniformity	T	Component	N/A	
3.4.7.3	Sampling Rates	N/A			
3.4.7.3.1	Raw Data Sampling Rate	A, I			
3.4.7.3.2	Radiometric Sampling Rate	A, I			

Para. No.	Description	Method (Note 1)	Level (Note 2)	Field of Regard	Comments
3.4.8	Radiometric Signal Processing	I			
3.4.8.1	Spatial Resolution and Noise Rejection	T, A	SS	N/A	
3.4.9	In-Flight Radiometric Calibration	I			
3.5.1.1	Boresight Placement	I, T, A	Inst	BS	OB launch locks on
	Elevation Scan Range	I, T	TSS	Az: –SE, SZ, +SE El: –SE, +SE IFC	
3.5.1.2	Elevation Scan Rate	T	TSS	Az: –SE, SZ, +SE El: scanning	Combine with verification of 4.4.10.2.1
3.5.1.3	Elevation Angle Knowledge	T, A	Inst	Az: –SE → +SE El: scanning	TBD increments in Az
3.5.1.4	Fixed Angle Mode	T	Inst	Az: –SE → +SE El: –SE → +SE	TBD increments in Az & El
4.4.5.1.1	Azimuth Axis	I	TSS		
4.4.5.1.2	Elevation Axis	I	TSS		
4.4.10.1	Boresight Angle & Axis Motion Ranges	T	TSS		
4.4.10.2	Elevation Requirements	N/A			
4.4.10.2.1	Scan Rate	T	TSS	Az: –SE, SZ, +SE El: scanning	Combine with verification of 3.5.1.2
4.4.10.2.2	Elev. Angle Knowledge Requirements	T	TSS	Az: –SE → +SE El: scanning	TBD increments in Az
4.4.10.2.3	Elevation Angle Jitter Requirements	T	TSS	Az: -SE, SZ, +SE El: -SE, SZ, +SE	9 points
4.4.10.3.3	Azimuth Pointing Accuracy	T	TSS	Az: –SE → +SE El: SZ	TBD increments in Az
4.4.10.3.4	Azimuth Angle Jitter Req.	T, A	TSS	Az: –SE, SZ, +SE El: scanning	
4.4.10.3.5	Azimuth Angle Knowledge Resolution and Sampling	I, T	Component & TSS	N/A	

NOTES:

(1) T = Test, A = Analysis, I = Inspection

(2) Inst = Instrument; TSS = Telescope Subsystem; DSS = Detector Subsystem; SS = Relevant Subsystem(s)

(3) SZ (Scan Zero): 0° for Azimuth
25.3° for Elevation
BS (Boresight): SZ on Az and El

(4) Scan Extremes: Azimuth: -SE = –43°, +SE = +21°
Elevation: –SE = 22.08°, +SE = 27.33°

(5) IFC: Azimuth = 52°, Elevation = 22° (nominal IFC view)

Addendum 1 is the relevant paragraphs from the ITS that were in effect at the time of this TC.

ADDENDUM 1

Relevant ITS Paragraphs (Rev M)

3.3.1 Vertical Field of View

The Instrument shall be designed to produce, in the atmosphere, an image of the field stop of each channel that has a nominal vertical dimension of 1 km at a distance of 3000 km.

3.3.2 Vertical Response

The end-to-end response of each spectral channel to a line source perpendicular to the ILOS, parallel to the IRCF X-Y plane, and moving parallel to the IRCF Z axis shall be a function with a full width at half maximum (FWHM) of 1.00 km +0.05/-0.1 km.

The integrated vertical response between the half-maximum points must be at least 80% of the total integrated response. Define the center of the vertical IFOV as the midpoint between the half-maximum points and let Δz be the distance (in km at the limb) from this center. Then for $\Delta z = 0.75$ km, the integrated response over the spatial interval $-\Delta z$ to $+\Delta z$ must be at least $(100 - 0.4\lambda)\%$ of the total integrated response, where λ is the central wavelength (in μm) of the channel; for $1 \leq \Delta z \leq 4$, the integrated response over the spatial interval $-\Delta z$ to $+\Delta z$ must be at least $(100 - 0.25\lambda / \Delta z^{1.15})\%$ of the total integrated response; and for $\Delta z > 4$, the vertical response function shall be governed by the Out-of-Field Response requirement in Section 3.3.5.

The requirements of this section apply only for ILOS elevation directions corresponding to the atmospheric sounding ranges specified in Table 3.4.3-1 and at a scanner azimuth setting of zero. At other azimuth angles the vertical response FWHM must not increase by more than the amount attributable to the image rotation produced by the scan geometry.

3.3.3 Vertical Response Stability

3.3.3.1 Within a Single Channel

The long-term stability of the static (neglecting jitter) vertical IFOV profile of each channel between the initially determined 0.2% relative response points shall be such that the relative response averaged over any interval equal to one tenth of the IFOV in the vertical spatial dimension shall not change by more than 0.4% of the maximum response, over the lifetime of the Instrument in orbit.

Between the initially determined 0.2% relative response points, the uncertainty in the relative response averaged over any interval equal to one tenth of the IFOV in the vertical spatial dimension, due to ILOS jitter, shall not exceed 0.5% of the maximum response.

3.3.3.2 Between Channels

Over the lifetime of the Instrument in orbit, the change in vertical registration of the centroid of the vertical response function of any channel with respect to that of the center channel in the field stop array, shall not exceed 1.0 arcsec.

3.3.4 Horizontal Field of View

In the horizontal direction, the IFOV in the atmosphere at the tangent point, for each channel, shall not exceed 72 km. A horizontal IFOV of 10 km between the 50% relative response points is recommended provided that this is consistent with meeting all radiometric requirements.

3.3.5 Out-of-Field Response

For each channel, while viewing either the atmosphere or the IFC blackbody, the integrated response (including optical crosstalk) that corresponds to scene radiance from points in the FOV with $\Delta z > 4$ (see Section 3.3.2) must be less than the greater of: (1) 0.4% of the total integrated response or (2) 100% of the specified radiometric noise (TBV), with 25% as the design goal. The HIRDLS document TC–HIR–90 specifies the atmospheric scene radiances that must be used to demonstrate compliance with this requirement.

3.4 Radiometric Specifications

Unless otherwise stated, the setting and/or measuring of radiometric parameters during ground testing and calibration shall be done with the chopper operating and the chopper reference view at the temperature expected during orbital operation.

3.4.1 Channel Spectral Response

The channel spectral response bands are specified in Table 3.4.1-1.

3.4.2 Spectral Response Stability

The stability of the overall spectral response profile of each channel between the start of Instrument calibration and EOL shall be as follows:

a. Between the initially-determined 1% relative response points (RRPs) the average response over a resolution interval of 1.0 cm^{-1} positioned at any 0.3 cm^{-1} increment on the wavenumber axis shall change by no more than ± 0.5% of the peak response.

b. Between the initially-determined 0.2% RRPs but outside the initially-determined 1% RRPs the average response over a resolution interval of 1.0 cm^{-1} positioned at any 0.3 cm^{-1} increment on the wavenumber axis shall change by no more than 50% of the measured amplitude value.

c. These stability requirements shall be met over a temperature range of 60 K to 80 K of the focal-plane assembly.

3.4.3 Out-of-Band Response

For each channel, over the spectral interval 350 cm^{-1} to 2140 cm^{-1} and outside the 0.2% relative response points of the spectral response, the overall response of the instrument relative to the peak inband response shall not exceed the values in the Out-of-Band Response column of Table 3.4.3-1. This requirement shall apply when the Instrument is viewing either the atmosphere within the atmospheric sounding range or the IFC black body.

3.4.4 Radiometric Performance

3.4.4.1 Radiometric Accuracy

The maximum error in the measurement of atmospheric emission over the operational elevation scan range shall not exceed:

a. for channels 2-5, the RSS of 0.5% of the atmospheric radiance and 50% of the maximum radiometric noise specified for that channel in Table 3.4.1-1.

b. for all other channels, the RSS of 1.0% of the atmospheric radiance and 100% of the maximum radiometric noise specified for that channel in Table 3.4.1-1.

3.4.4.2 Radiometric Channel Gain

The analog gain of each radiometric channel when the Instrument is viewing a blackbody at a temperature of 300 K, shall be set according to whichever of the following criteria gives the lower gain value:

a. The noise level at the digitizer input corresponds to 10-15 quantization levels, peak-to-peak.

b. The telemetry data output has a value of 44000 ± 5% (assuming a 16-bit unsigned representation).

3.4.4.2.1 Radiometric Channel Gain Stability

The 10-second running average of the overall gain of each radiometric channel, between the entrance pupil and the quantizer output, shall not change at a rate greater than 1 part in 10^5 per second.

3.4.4.3 Radiometric Channel Offset

The analog offset of each radiometric channel shall be set such that the telemetry data output value is 1000 ± 250 (assuming 16-bit unsigned representation) when the Instrument is viewing a blackbody at a temperature of ≤ 100 K.

3.4.4.3.1 Radiometric Channel Offset Stability

TBD

3.4.4.4 End-to-End Channel Linearity

The pre-calibration radiometric channel linearity of the Instrument, from the entrance pupil to the telemetry output, shall be such that if:

a. Channel gains and offsets have been set according to the requirements of Sections 3.4.4.2 and 3.4.4.3

b. Measured channel spectral responses and calculated AΩ products are assumed to be correct

c. Each channel is assumed to have a linear radiometric transfer function between end points established by viewing blackbody scenes at <100 K and 300 K

and if at any intermediate scene temperature between 100 K and 300 K:

d. An apparent scene temperature T_S be established by calculating the mean of the scene temperatures inferred from the outputs of all channels

e. For each radiometric channel a predicted output be calculated based on a scene temperature T_S

then, the actual value of the output of each channel shall differ from the predicted output of that channel by no more than 1%.

3.4.4.5 Electrical Crosstalk between Radiometric Channels

The telemetry output of any "receptor" channel shall not change by more than the greater of 1 quantization level or 0.02% of the value corresponding to the Maximum Expected Input Radiance listed in Table 3.4.1-1, as the signal level in any "donor" channel is varied over its full dynamic range as defined in Section 3.4.6.

3.4.5 Radiometric Noise

For each channel the Noise Equivalent Radiance (NEN) of the signal path from the entrance pupil to the output of the digitizer shall be less than or equal to that specified in the "Radiometric Noise" column in Table 3.4.1-1. This requirement shall apply over a temperature range of 60 K to 65 K at the focal plane assembly.

Channel Number	Species	50% Channel Passband (cm^{-1}) (μm)	5% Channel Passband (cm^{-1}) (μm)	Maximum Expected In-orbit Input Radiance ($W \cdot m^{-2} \cdot sr^{-1}$)	Radiometric Noise (10^{-4} W·$m^{-2} \cdot sr^{-1}$) **
1	N_2O, aerosol	563–588 17.01–17.76	555.5–595.5 16.79–18.00	3.90	12.0
2	CO_2	600–615 16.26–16.67	595.5–619.5 16.14–16.79	2.34	6.3
3	CO_2	610–640 15.63–16.39	601.0–649.0 15.41–16.64	4.66	5.9
4	CO_2	626–660 15.15–15.97	615.8–670.2 14.92–16.24	5.25	6.0
5	CO_2	655–680 14.71–15.27	647.5–687.5 14.55–15.44	3.82	4.3
6	aerosol	821–836 11.96–12.18	816.5–840.5 11.90–12.25	2.55	1.9
7	$CFCl_3$	835–853 11.72–11.98	829.6–858.4 11.65–12.05	3.06	2.0
8	HNO_3	860–905 11.05–11.63	846.5–918.5 10.89–11.81	7.19	2.1
9	CF_2Cl_2	915–933 10.72–10.93	909.6–938.4 10.66–10.99	2.51	2.0
10	O_3	990–1010 9.90–10.10	984.0–1016.0 9.84–10.16	2.04	1.5
11	O_3	1011–1048 9.54–9.89	999.9–1059.1 9.44–10.00	4.64	2.4
12	O_3	1120–1140 8.77–8.93	1114.0–1146.0 8.73–8.98	1.56	0.96
13	aerosol	1200–1220 8.20–8.33	1194.0–1226.0 8.16–8.38	1.30	1.1
14	N_2O_5	1229–1260 7.94–8.14	1219.7–1269.3 7.88–8.20	1.86	1.1
15	N_2O	1256–1282 7.80–7.96	1248.2–1289.8 7.75–8.01	1.47	1.1
16	$ClONO_2$	1278–1299 7.70–7.82	1271.7–1305.3 7.66–7.86	1.13	1.1
17	CH_4	1324–1369 7.30–7.55	1310.5–1382.5 7.23–7.63	2.10	1.2
18	H_2O	1385–1435 6.97–7.22	1370.0–1450.0 6.90–7.30	1.97	1.2
19	aerosol	1402–1416 7.06–7.13	1397.8–1420.2 7.04–7.15	0.56	1.3
20	H_2O	1422–1542 6.49–7.03	1386.0–1578.0 6.34–7.22	3.91	1.6
21	NO_2	1582–1634 6.12–6.32	1566.4–1649.6 6.06–6.38	1.18	1.1

**These values assume an effective measurement bandwidth of 7.5 Hz, which is the nominal bandwidth for the global mode.

Table 3.4.1-1 Spectral Channels

Channel Number	Species	Atmospheric Sounding Range* (km)	Minimum Space View† (km)	Out-of-Band Response
1	N_2O, aerosol	8–70	75	1.2E-4
2	CO_2	8–40	95	2.0E-4
3	CO_2	8–60	125	3.9E-4
4	CO_2	15–60	140	4.4E-4
5	CO_2	30–105	150 (**TBV**)	3.2E-4
6	aerosol	8–55	65	9.4E-6
7	$CFCl_3$	8–50	60	1.2E-5
8	HNO_3	8–70	65	2.7E-5
9	CF_2Cl_2	8–50	65	1.2E-5
10	O_3	8–55	80 (**TBV**)	1.5E-5
11	O_3	30–85	85 (**TBV**)	2.9E-4
12	O_3	8–55	80 (**TBV**)	3.8E-5
13	aerosol	8–55	65	6.8E-6
14	N_2O_5	8–60	70	1.8E-5
15	N_2O	8–70	75	1.7E-5
16	$ClONO_2$	8–70	75	1.5E-5
17	CH_4	8–80	75	2.3E-5
18	H_2O	8–40	75	1.2E-5
19	aerosol	8–55	65	6.4E-6
20	H_2O	15–85	75	4.3E-5
21	NO_2	8–70	70	1.4E-5

* These ranges represent the tangent heights over which useful retrievals will be possible, plus an additional 15 km at the upper boundary, which is required for the retrieval process.

† These minimum heights do not include the additional 10 km required by IRD Section 2.7.1.

Table 3.4.3-1 Critical Atmospheric Tangent Heights

3.4.6 Dynamic Range

The radiometric performance requirements of Section 3.4.4 shall be met for any scene radiance over the dynamic range of zero (cold space view) to 1.25 times the maximum expected radiances listed in Table 3.4.1-1.

3.4.7 Radiometric Digitization

3.4.7.1 Radiometric Quantization Error

For each channel, the radiance-equivalent noise at the entrance pupil attributable to quantization error shall not exceed 0.5*NEN/SQRT(12) where NEN is the Radiometric Noise specified in Table 3.4.1-1.

3.4.7.2 Radiometric Quantization Step Size Uniformity

The radiometric signals must be quantized with a resolution of one part in 2^{16}, and the step size must be uniform to within $\Delta / 2$ (where Δ is the quantization step size).

3.4.7.3 Sampling Rates

3.4.7.3.1 Raw Data Sampling Rate

The detector outputs of all spectral channels shall be sampled twice per cycle of the optical chopping waveform. Sampling shall occur at a phase delay with respect to the optical chopping waveform that is separately programmable for each channel.

3.4.7.3.2 Radiometric Sampling Rate

The effective radiometric sampling rate for a spectral channel is the rate at which radiometric data for that channel are output to the Science Data telemetry stream.

In the Global Mode, the effective radiometric sampling rate for all channels shall be at least 80 samples/s. Programming flexibility shall allow the allocated telemetry bandwidth to be used for a subset of the spectral channels, sampled at a rate higher than that of the Global Mode.

3.4.8 Radiometric Signal Processing

The Instrument shall provide programmable processing of the detector output samples that includes, as a minimum, quantization, synchronous demodulation and digital filtering.

3.4.8.1 Spatial Resolution and Noise Rejection

In the global mode, the signal-processing system shall pass signals with atmospheric spatial frequencies from 0 to 1 cycle/km. Over the spatial frequency range 0–0.5 cycle/km, the gain and the attenuation of the signal must be constant to within 0.1 dB; for 0.5–1 cycle/km, they must be constant to within 0.5 dB. Any noise signals that might be aliased into the signal band by the sampling process must be attenuated by at least 20 dB, for all of the operational modes.

3.4.9 In-Flight Radiometric Calibration

The in-flight calibration shall be established using space views and the view of an on-board blackbody source. For each channel the space view shall be at or above the minimum tangent height given in Table 3.4.3-1, and via the same optical train used for normal atmospheric scanning. The blackbody view shall be via the same optical train used for normal atmospheric scanning with the addition of, at most, one fixed temperature-controlled mirror between the blackbody source and the scan mirror.

3.5.1.1 Elevation Scan Range

The boresight placement and ILOS scan range requirements are given in Table 3.5.1.1-1.

Parameter	Elevation
Boresight-to-IRCF	25.3°± 300"
ILOS Scan Range (relative to Boresight)	–3.22° +2.03°
Nominal IFC View	22.0°

Table 3.5.1.1-1 Boresight and ILOS Elevation Scan Range

3.5.1.2 Elevation Scan Rate

The Scanner shall be capable of moving the ILOS in elevation at constant angular rates from 0.1°/s to 1.0°/s adjustable in increments not greater than 0.01°/s. During a nominally constant-rate vertical scan segment of duration up to 10 s, excluding any specified settling time, the ILOS scan rate relative to the SRCF, and smoothed by the PLPF, shall not vary by more than ±5.0% of the mean rate over the segment.

The elevation scan rate shall be programmable, with the capability of executing up to four constant-rate segments within a single elevation scan (constant direction of motion).

3.5.1.3 Elevation Angle Knowledge Specifications

The requirements in this section are on knowledge of relative elevation angles. There are no requirements on absolute elevation angle knowledge, other than as implied by Section 3.5.1.1 above, nor on control of relative elevation angle, other than as implied by Section 3.5.1.2 above.

The following requirements on relative elevation angle knowledge, with respect to inertial space, shall be met in the on-orbit thermal and vibrational environments specified in Section 3.11:

a. Within any single global-mode vertical scan (duration up to 10 s), the random error in the measurement, filtered by the PLPF, of the relative elevation angle between any two radiometric samples shall not exceed 2.1 arcsec, 3 σ. It may be assumed for the purposes of this requirement that the scan mirror has not been commanded to move in azimuth over this time interval.

b. Within any single global-mode vertical scan (duration up to 10 s), the systematic error in the measurement of the relative elevation angle between any two radiometric samples, shall not exceed the greater of 0.25% of the relative elevation angle or 0.35 arcsec. It may be assumed for the purposes of this requirement that the scan mirror has not been commanded to move in azimuth over this time interval.

c. Between any two adjacent global-mode elevation scans, separated in time by any interval in the range of 10 s to 66 s, or by any interval in the range of p-132 s to p+132 s, where p is the orbital period, the total error in the measurement, filtered by the PLPF, of the relative elevation angle between any two radiometric samples (one each from the two adjacent elevation scans), shall not exceed 4.2 arcsec, 3 σ. This requirement shall apply for any azimuth separation between the samples within the ILOS azimuth scan range, and the azimuth angle may have been set to any value or sequence of values within the available range during the separation interval.

   It is recognized that some ground data processing may be required to meet this requirement over the one-orbit interval.

3.5.1.4 Fixed Angle Mode

The Instrument shall be capable of holding, by IPS command, a fixed LOS elevation angle (as defined in Figure 3.5-1):

a. absolutely to within 0.025° (90 arc sec) of any specified angle within the elevation scan range, relative to the IRCF

b. commandable in increments of 2 arcsec or less

c. with a mean value, averaged over any 1 minute period, that is constant to within 4 arcsec relative to any other stationary setting within the previous 60 minutes of time, assuming that all relevant temperatures have remained stable to 1 °C or less

d. with integrated pointing motions, relative to the IRCF, not exceeding 0.7 arcsec, 3 σ, assuming a perfectly noise-free instrument support structure

4.4.5.1.1 Azimuth Axis

The Scanner azimuth axis of rotation shall be fixed with respect to the Optical Bench and shall:

a. be parallel to the TRCF Z-axis within 60 arcsec

b. pass within 1 mm of the point of intersection of the POA and the scan mirror surface when the scan mirror is in the Scan Datum position

4.4.5.1.2 Elevation Axis

The Scanner elevation (moveable) axis of rotation shall be:

a. orthogonal to within 0.05° of the azimuth axis

b. parallel to within 0.025° of the scan mirror surface

c. located within 1 mm of the point of intersection of the POA with the scan mirror surface, for all mirror positions within the operational scan range

4.4.10.1 Boresight Angle and Axis Motion Ranges

The boresight placement, relative to the TRCF, and the minimum required ranges of motion for the Scanner axes, are given in Table 4.4.10.1-1.

NOTE: The required axis motion ranges are given in shaft angles (not LOS angles) relative to the Scan Datum Position, and include all required scan geometry factors and margins.

Parameter	Elevation	Azimuth
Boresight-to-TRCF	25.3°± 60"	0°± 60"
Axis Motion Ranges	–2.27° to +1.62°	–24.5° to +29°

Table 4.4.10.1-1 Boresight Angle and Axis Motion Ranges

4.4.10.2 Elevation Requirements

4.4.10.2.1 Scan Rate

Note that the ILOS elevation angle in this requirement is referred to the SRCF.

The ILOS elevation scan rate shall be programmable, with the capability of executing up to four constant-rate segments, of different rates, within a single elevation scan. The rate of each constant-rate segment

shall be programmable over the range 0.1°/s to 1.0°/s in increments no greater than 0.01°/s. After a rate transition, the scanner shall settle to within ±5.0% of the new commanded rate within 0.1 s.

During a constant-rate scan segment, and assuming the vibration environment defined in Section 3.11.7, the scan rate, after the settling time specified above, and smoothed by the PLPF, shall not vary by more than ±5.0%. If a system employing motion sensors mounted to the Optical Bench is used for meeting this requirement, the outputs of the motion sensors shall be available to the IPS on demand at any rate up to the radiometric chopping rate, for diagnostic use.

4.4.10.2.2 Elevation Angle Knowledge Requirements

Note: See definitions in Section 3.5.

The following requirements on elevation angle measurements, relative to the TRCF, shall be met in the on-orbit thermal and vibrational environment specified in Section 3.11:

a. Within any one Global Mode elevation scan (nominal duration 10 s) the random error in the measurement of the relative elevation angle between any two radiometric samples, measured with respect to the TRCF and filtered by the PLPF, shall not be more than 1.2 arcsec, 3 σ. It may be assumed for the purposes of this requirement that the scan mirror has not been commanded to move in azimuth during the elevation scan.

b. Within any one Global Mode elevation scan (nominal duration 10 s) the systematic error in the measurement of the relative elevation angle between any two radiometric samples, measured with respect to the TRCF, shall not exceed the greater of 0.14% of the relative angle or 0.2 arcsec. It may be assumed for the purposes of this requirement that the scan mirror has not been commanded to move in azimuth during the elevation scan.

c. For any two vertical scans (here designated Scan A and Scan B) separated in time by any interval in the range of 10 s to 66 s, or by any interval in the range of p-132 s to p+132 s, where p is the orbital period, the total error in the measurement of relative elevation angle between any radiometric sample in Scan A and any radiometric sample in Scan B, measured with respect to the TRCF and filtered by the PLPF, shall not exceed 2.0 arcsec, 3 σ. This requirement shall apply for any azimuth separation between the samples within the ILOS azimuth scan range.

4.4.10.2.3 Elevation Angle Jitter Requirements

Note: See definitions in Section 3.5.

The following requirements on jitter shall be met in the on-orbit thermal and vibrational environments specified in Sections 3.11.6 and 3.11.7:

a. The integrated in-band LOS jitter, relative to inertial space shall not exceed 0.2 arcsec, 3 σ.

b. The total synchronous and in-band jitter relative to inertial space shall not exceed 0.03 arcsec, 3 σ.

c. The total integrated vertical LOS jitter relative to inertial space shall not exceed 0.2 arcsec, 3 σ.

4.4.10.3.3 Azimuth Pointing Accuracy

The following requirements shall be met over the on-orbit thermal and dynamic environments specified in Sections 3.8 and 3.11:

a. For any commanded azimuth angle within the azimuth scan range, the actual absolute angle, α_A, measured with respect to the TRCF shall equal the commanded angle α_C within the following limit at all times between 2.0 and 10.0 seconds (See Figure 4.4.10.3.1-1) following the initiation of an azimuth step of up to 10°:

$$|\alpha_A - \alpha_C| \leq 0.02°$$

b. For any two Global Mode vertical scans (of approximately 10s duration each) separated in time by any interval in the range of 10 s to 66 s, or by any interval in the range of p-132 s to p+132 s, where p is the orbital period, the difference between the mean azimuth angle of the first vertical scan and the mean azimuth angle of the second vertical scan, relative to the TRCF, shall be known with an unsigned error of at most 72 arcsec. This shall apply where the two azimuth settings are placed anywhere within the azimuth scan range specified in Table 3.5.2.1-1.

END